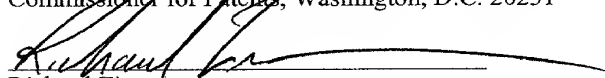


JOINT INVENTOR

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Richard Zimmermann

## APPLICATION FOR UNITED STATES LETTERS PATENT

# SPECIFICATION

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TO ALL WHOM IT MAY CONCERN:

Be it known that we, Ron Rotstein, Arlington Heights, Illinois; Yuda  
Yehuda Luz, Buffalo Grove, Illinois; Robert T. Love, Barrington, Illinois; Dennis Ray  
Schaeffer, Buffalo Grove, Illinois; Jiangnan (Jason) Chen, Darien, Illinois; and Collin  
Frank, Chicago, Illinois, have invented new and useful **A METHOD AND  
APPARATUS FOR PSEUDO-RANDOM NOISE OFFSET REUSE IN A MULTI-  
SECTOR CDMA SYSTEM**, of which the following is a specification.

# **A METHOD AND APPARATUS FOR PSEUDO-RANDOM NOISE OFFSET REUSE IN A MULTI-SECTOR CDMA SYSTEM**

## **FIELD OF THE INVENTION**

5           The present invention relates generally to communication systems,  
and, more particularly, to a method and apparatus that achieves reuse of  
pseudo-random noise indices or offsets in a multi-sector communications  
systems such as a CDMA system.

## **BACKGROUND OF THE INVENTION**

10           Typically in wireless communication systems such as that illustrated in  
FIG. 1, a base station 102 that transmits to and receives from mobile units 104  
is used to create what is termed a cell. In CDMA wireless systems, in  
particular, optimization is a critical consideration that has significant impact  
15   on the performance and capacity of a CDMA system. Particularly in both 2G  
and 3G CDMA systems, the need to enhance the capacity of the systems is  
increasing. One method for optimizing capacity in a CDMA cell is to  
minimize areas suffering from pilot pollution. Typically a base station 102  
has a number of antennas, each of which is used to form a respective sector  
20   within a CDMA cell. Each CDMA sector sends its own pilot channel  
requiring its own corresponding pseudo-random noise (PN) offset. If a mobile  
unit 104 is in a location within the CDMA cell where numerous pilot channels  
are received with relatively equal signal strength, pilot pollution likely will  
result. This pollution is detrimental because it may cause dropped calls and  
25   decreased capacity. Thus, the more sectors per cell may result in increased  
pilot pollution.

As the number of sectors per site or cell increases, however, so does the capacity of the system as those illustrated by the table in FIG. 2. As is shown, the increase in capacity from 1 to 12 sectors, for example, is over six times gain and the Erlangs for the site or cell increases from approximately 21 to 134. As mentioned previously, however, the increase in the number of sectors may increase degradation of the CDMA performance due to pilot pollution. A further problem is that more sectors require more antennas, power amplifiers and cables thereby increasing the cost of the system. As an example, a 12 sector system would require 24 receive antennas (i.e., 12 sectors x 2 for receive diversity) and 24 transmit antennas (12 sectors x 2 for transmit diversity).

Hence, there is a need to increase the capacity of CDMA systems by increasing the number of sectors while decreasing pilot pollution and reducing the cost outlay for system hardware.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

Features and advantages of the disclosed system and method will be apparent to those of ordinary skill in the art in view of the detailed description of preferred embodiments that is made with reference to the drawings, a brief description of which is provided below.

FIG. 1 is a diagram illustrating components of a CDMA cell.

FIG. 2 is a table illustrating the increase capacity of a CDMA cell as the number of sectors is increased.

FIG. 3 illustrates a CDMA cell having multiple sectors constructed in accordance with the teachings of the present invention.

FIG. 4 illustrates an example of a base station antenna configuration constructed in accordance with the teachings of the present invention.

FIG. 5 illustrates a block diagram of the reverse link receiver portion of the system at a base station in accordance with the teachings of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In order to enhance the capacity of a CDMA system, a method and apparatus are disclosed that include reuse or sharing of pseudo-random noise (PN) offsets within a cell of a wireless communication system such as a multi-sector CDMA system. Reuse of PN offsets affords a system where less PN offsets are needed. The disclosed method and apparatus further employ adaptive antenna arrays or a number of fixed narrow beams to form the sector areas within the CDMA cell. Moreover, the disclosed method and apparatus detect the existence of multi-path links between a base station and a mobile unit that are sharing or reusing common PN offsets. A forward link data channel is then established between both sectors, which provides desirable transmit diversity.

FIG. 3 illustrates an exemplary sector pattern of a CDMA cell in accordance with the teachings of the invention. A base station 202 includes a number of transmit and receive antennas (not shown) that are used to establish multiple sectors that emanate in beam patterns from the base station 202. The particular pattern illustrated in FIG. 3 utilizes a 12 beam pattern corresponding to a 12 sector system. The antenna arrays are set to form 12 sector beams 204, 206, 208, 210, 212, 214, 216, 218, 220, 222, 224 and 226 with each sector

covering approximately 30° of the 360° coverage area. In the particular system shown, four PN offsets are used with each offset being repeated three times within the system. As will be appreciated by those skilled in the art, other configurations may be envisioned such as the use of three PN offsets repeated four times or six PN offsets repeated two times. Irrespective of the particular configuration that is to be used, the same PN offset should not be used in adjacent sectors and at least one PN offset should be used more than once at a given site.

As illustrated in FIG. 3, four PN offsets labeled A-D are utilized in the illustrated system. As is shown, the same PN offset is spatially separated by a predetermined distance or angle and occurs in a repeating sequence of the PN offset sectors (e.g., A, B, C, D). For example, in the present disclosed system utilizing four PN offsets, beam sectors 204 and 212 that share the PN offset A are separated by 120°. Thus, for the present disclosed system the spatial degree of separation for sectors sharing the same PN offset is 120°. As an alternate example, if the system utilized three PN offsets being repeated four times, the spatial separation between sectors sharing the same PN index would be 90°.

Each of the PN offsets A-D has associated with its own pool of Walsh codes, such that the entire system has four times the number of Walsh codes in its pool as that of a single sector. Thus, all of the identical PN offsets are kept orthogonal to each other, which prevents cross-sector cross-talk. Additionally, pilot pollution in a mobile unit 203 is limited by the use of relatively narrow beams, thereby limiting the area that is covered by multiple PN offsets.



As a means to perform the reverse link scan, the method and apparatus constructed according to the teachings of the present invention preferably utilize an adaptive antenna array. An example of the topology of such an array is illustrated in FIG. 4, which shows a top view of the adaptive antenna array 400. Within the array 400 are three individual antenna arrays 402A, 402B and 402C whose faces are disposed at angles of approximately 60° with respect to one another, thereby forming a triangular arrangement. Each array 402 is used to cover 120° of the CDMA cell. Additionally, each one of the arrays 402 includes four specific adaptive antennas 404 that are directed by an antenna beam steering control to cover a particular 30° sector. Thus, the full 360° of the CDMA cell are covered by the 12 individual adaptive antennas 404. It is noted that the configuration illustrated in FIG. 4 is merely exemplary and other antenna topologies may be utilized, such as four adaptive arrays having three adaptive antennas each or simply 12 individual antenna arranged in a circular configuration to effect the exemplary pattern of FIG. 3.

It is noted that the adaptive antenna array illustrated in FIG. 4 is utilized for both the reverse link or forward link of the CDMA site. Accordingly, only one physical adaptive antenna array is required for the forward link or transmission side of the base station and the reverse link or receive portion of the base station. Additionally, redundancy may be introduced to the system by adding additional antenna arrays for the forward and reverse links. However, the method and apparatus disclosed according to the teachings of the invention eliminate the need for redundant antennas, which are typically used in the conventional art for transmit and receive

diversity, since the use of multi-path connections achieves transmit diversity without the need for additional redundant antennas.

As multi-path connections to the mobile unit 203 shown in FIG. 3 is characterized, the base station 202 may utilize this information to determine if a significant multi-path link exists from either sectors 208 or 216, continuing with the previously described example. The forward link transmitter of the base 202 is then configured to transmit the sector 224 data onto one or both of sectors 208 and 216 to this specific mobile unit 203. Hence, the effect of this multi-path transmission is a even “softer” handoff diversity in the mobile unit 203 than is known previously in the conventional art.

FIG. 5 illustrates a block diagram of the mechanism used in the reverse link portion of the base station 202 to achieve scanning and characterization of the multi-path manifold for a CDMA cell. In particular, a plurality of antennas  $A_1, A_2 \dots A_n$  for receiving transmitted signals on the reverse link are connected to respective receivers RCVR1 – RCVR $_n$  (501 $_1$  - 501 $_n$ ). The variable “n” represents the number of sectors within the CDMA cell. In the example of FIG. 3, this “n” number of sectors is equal to 12. Once the information is received by the receivers 501, it is fed to searchers SRCHR1 – SRCHR $_n$  (502 $_1$  - 502 $_n$ ) corresponding to each receiver 501. The searchers 502 are used to accomplish scanning to determine which corresponding sectors may be covering a particular mobile user. The information from the searcher blocks 502 is passed to a resource management decision logic 504, which is used to characterize the multi-path manifold and decide if data should be transmitted to the mobile user from multiple sectors to establish multi-path links. Once this determination is arrived at by the resource management

decision logic 504, a control signal is passed to the forward link transmitter 505 for execution of the particular multi-path transmission. FIG. 5 also includes an optional antenna beam steering control 503 that is used to direct the receivers 501 and their respective antennas to cover their corresponding sector areas. However, it is noted that if single antennas are used instead of an adaptive antenna array, the antenna beam steering control 503 is not necessary.

As will be appreciated by those skilled in the art, the disclosed method and apparatus reduces the number of PN offsets utilized by reusing or sharing PN offsets among two or more sectors in a CDMA cell. Additionally, by utilizing an adaptive antenna array, determination of multi-path links serves to maximize the capacity of a base site, which is particularly useful for high data rate users. Moreover, the disclosed method and apparatus afford an increase in site capacity to approximately 135 erlangs while maintaining the antenna complexity of a six sector level. A six sector system requires 12 antenna elements, 6 for the main branch and 6 for the diversity branch. The exemplary disclosed method utilizes the same number of antennas to provide a significant capacity enhancement (i.e., 12 sectors).

The foregoing description has been presented for the purposes of illustration and description. It is not intended to be exhausted or to limit the teaching of the invention to the exemplary embodiments disclosed. Many modifications and variations are possible in light of the above teachings and it is intended that the scope of the invention be limited not by this detailed description, but rather by the claims appended hereto.